CLAIMS

1. A first component of a field assemblable tool assembly including at least one sensor and adapted for insertion into a well or other hole, the tool assembly including the first component and at least a second component that are field assemblable, with the second component including a terminal end of a cable, the cable including at least two electrical conductors through which external power is deliverable to the tool assembly, the first component comprising:

a computing unit disposed within the housing, the computing unit including a processor and memory having stored therein instructions readable and executable by the processor to direct at least one operation of the tool assembly;

the computing unit, when operably connected with the sensor in the tool assembly, being capable of directing obtainment from the sensor of sensor readings corresponding to at least one monitored condition in the vicinity of the sensor, each said sensor reading comprising at least one sensor output signal including sensor reading data corresponding to the at least one monitored condition, the computing unit being capable of processing the sensor reading data and storing the sensor reading data in the memory;

wherein, when the first component is assembled with the second component, the computing unit being capable of being powered by electrical power supplied from an external power source through the electrical conductors of the cable, and wherein the first component has a longitudinal axis extending in a direction from the first longitudinal end of the housing toward the second longitudinal end of the housing, a cross-section of the first component, taken substantially perpendicular to the longitudinal axis at any longitudinal location along the first component, fits entirely inside a circle having a diameter of smaller than about 1 inch.

2. The first component of claim 1, wherein the cross-section of the first component fits entirely inside a circle having a diameter of no larger than about 0.9 inch.

3. The first component of claim 1, wherein the cross-section of the first component fits entirely inside a circle having a diameter of no larger than about 0.8 inch.

4. The first component of claim 1, wherein the cross-section of the first component fits entirely inside a circle having a diameter of no larger than about 0.75 inch.

5. The first component of claim 1, wherein the first component is rotatably engageable with the second component through complementary engagement structures to physically secure the second component to the first component and to electrically interconnect the first component with the cable;

electrical interconnection between the first component and cable being automatically made when the first component and the second component are rotatably engaged, substantially without any keyed orientation between the first component and the second component.

6. The first component of claim 1, wherein the cable is a vented cable, having a first fluid conductive path extending along the length of the cable, and the first component includes a second fluid conductive path in fluid communication with the first fluid conductive path when the first component and the second component are assembled into the tool assembly, so that when the sensor is a pressure sensor, the tool assembly is capable of taking pressure readings adjusted for atmospheric pressure.

7. The first component of claim 1, wherein the sensor is part of the first component adjacent the second and is disposed inside of the housing.

8. The first component of claim 1, further comprising an energy storage unit, disposed within the housing , capable of supplying electrical power to at least the computing unit at a voltage of smaller than about 4 volts.

9. The first component of claim 8, wherein the computing unit is located on a main circuit board disposed within the housing, the main circuit board operating at a voltage of smaller than about 4 volts.

10. The first component of claim 9, wherein the energy storage unit has a first end and a second end opposite the first end, a first electrode of the energy storage unit being located at the first end and a second electrode of the energy storage unit being located at the second end, the first electrode being located adjacent the main circuit board and the second electrode being located away from the main circuit board; and

a flexible circuit unit completes electrical connection between the main circuit board and the second electrode of the energy storage unit, the flexible circuit unit extending substantially entirely across the length of the energy storage unit as measured between the first end and the second end of the energy storage unit.

11. The first component of claim 10, wherein the flexible circuit unit comprises electrically conductive features supported on a flexible substrate.

12. The first component of claim 11, wherein the flexible circuit unit has a first end adjacent the main circuit board and a second end adjacent the second electrode of the energy storage unit;

the flexible circuit unit including, adjacent the second end of the flexible circuit portion, a conductive pad in energy contact with the second electrode of the electrical storage unit; and

the flexible circuit unit further comprising, adjacent the second end of the flexible circuit portion, electrical leads for electrically interconnecting the first component with the second component when the first component and the second component are assembled into the tool assembly, a cable to permit interconnection of the first component with an external device.

13. The first component of claim 12, wherein the main circuit board is located between the first longitudinal end of the housing and the energy storage unit and the second end of the flexible circuit unit being located between the energy storage unit and the second longitudinal end of the housing when the first component and the second component are assembled into the tool assembly; and

the energy storage unit is accessible for replacement through the second longitudinal end of the housing when the first component is disassembled from the second component, the flexible circuit unit has sufficient slack length to permit withdrawal of the second end of the flexible circuit unit from the second longitudinal end of the housing, to permit access for replacement of the energy storage unit through the second longitudinal end of the housing.

14. The first component of claim 8, wherein the energy storage unit comprises at least two AA cells in series.

15. The first component of claim 1, wherein the first component is operable in at least two modes, a first mode being an awake mode and a second made being a sleep mode.

16. The first component of claim 1, further comprising a capacitor disposed within the housing and electrically interconnected with the computing unit, the computer

unit including a real time clock/calendar and the capacitor having a sufficiently large capacitance to supply, when fully charged, power requirements of the real time clock/calendar for a duration of at least about 30 minutes.

17. The first component of claim 16, wherein the capacitor and the computing unit are both located on a main circuit board disposed within the housing.

18. The first component of claim 1, where the cable includes at least one communication line dedicated for communication external to the tool assembly; and

when the first component and the second component are assembled into the tool assembly, the computing unit being capable of directing transmission of communication signals via the at least one communication line.

19. The first component of claim 18, wherein the transmission of communication signals via the at least one communication line is according to a half-duplex communication protocol.

20. The first component of claim 1, wherein the computing unit is capable of directing obtainment of sensor readings according to at least two different sampling schedules, a first sampling schedule including a different interval between obtainment of sensor readings than a second sampling schedule, the computing unit further being capable of directing a change from the first sampling schedule to the second sampling schedule when the computing unit identifies the occurrence of a predefined event.

21. The first component of claim 20, wherein the predefined event is a predefined change between sensor readings.

22. The first component of claim 1, wherein the housing has a substantially tubular shape.

23. The first component of claim 1, wherein the first component and the second component are assembled into the tool assembly.

24. A first component adapted for assembly with at least a second component into a tool assembly, the tool assembly adapted for insertion into a well or other hole to monitor at least one condition existing in the well or other hole, the first component comprising:

a housing having a first longitudinal end and a second longitudinal end, a first engagement structure being located at one of the first longitudinal end and the second longitudinal end, the first engagement structure being rotatably engageable and rotatably disengageable with a complementary second engagement structure of the second component;

a computing unit disposed within the housing, the computing unit including a processor and memory having stored therein instructions readable and executable by the processor to direct obtainment of sensor readings from at least one sensor operably connected with the computing unit in the tool assembly;

wherein, rotatable engagement of the first engagement structure with the second engagement structure physically secures the second component to the first component and makes an electrical connection between the first component and the second component, the electrical connection comprising contact between at least a first side of a multiple connector unit and a plurality of electrical leads;

the multiple connector unit further comprising a second side, opposite the first side, and a plurality of isolated electrically conductive portions extending from at least the first side to the second side, the conductive portions being spaced so that the conductive portions, at the first side, make isolated electrical connections with the plurality of conductive leads, to provide electrically isolated interconnection paths to the plurality of electrical leads along the conductive portions from the first side to the second side of the multiple connector unit; and

wherein the first component includes one of the multiple connector unit and the plurality of electrical leads and the second component includes the other of the multiple connector unit and the plurality of electrical leads, the multiple connector unit and the plurality of electrical leads being located and oriented so that the contact between the multiple conductor unit and the plurality of electrical leads is made when the first engagement structure and the second engagement structure are rotatably engaged and the

contact between the multiple connector unit and the plurality of electrical interconnection leads is broken when the first engagement structure and the second engagement structure are rotatably disengaged.

25. The first component of claim 24, wherein the isolated conductive portions of the multiple connector unit are substantially parallel.

26. The first component of claim 25, wherein the conductive portions are spaced at a pitch of smaller than about 0.01 inch.

27. The first component of claim 24, wherein the multiple connector unit is an elastomeric electrical connector.

28. The first component of claim 27, wherein the elastomeric electrical connector comprises a flexible core and each said conductive portion comprises an electrically conductive line adjacent an exterior surface of the flexible core.

29. The first component of claim 28, wherein the electrically conductive lines are supported on a flexible substrate attached to the exterior surface of the flexible core.

30. The first component of claim 24, wherein the plurality of electrical leads and the multiple connector unit rotate relative to each other when the first engagement structure and the second engagement structure are being rotatably engaged.

31. The first component of claim 24, wherein the plurality of electrical leads is a first plurality of electrical leads, the first plurality of electrical leads being a part of one of the first component and the second component and the other of the first component and the second component including a second plurality of electrical leads; and

the multiple connector unit being sandwiched between and in contact with each of the first plurality of electrical leads and the second plurality of electrical leads when the first engagement structure and the second engagement structure are rotatably engaged.

32. The first component of claim 31, wherein the multiple connector unit is retained in a fixed orientation relative to the second plurality of electrical leads when the first engagement structure and the second engagement structure are being rotatably engaged.

33. The first component of claim 24, wherein each of the plurality of electrical leads is an electrically conductive feature supported on a surface of a substrate.

34. The first component of claim 33, wherein each said electrically conductive feature comprises at least an arc of a different concentric circle.

35. The first component of claim 34, wherein each said electrically conductive feature comprises a different concentric circle.

36. The first component of claim 35, wherein the plurality of electrical leads are supported on a first side of the substrate, and each of the plurality of electrical leads is connected with an electrically conductive bonding location supported on a second side of the substrate opposite the first side, each said bonding location providing a location for making an electrical connection to one of the electrical leads.

37. The first component of claim 24, wherein the plurality of electrical leads comprises at least 4 said electrical leads.

38. The first component of claim 36, wherein at least two of the electrical leads are dedicated to communication and at least two of the electrical leads are dedicated to delivering electrical power to the first component from an external power source.

39. The first component of claim 24, wherein the plurality of electrical leads comprises at least 6 said electrical leads.

40. The first component of claim 24, wherein the second component comprises the sensor, the sensor being electrically interconnected with the computing unit when the first engagement structure and the second engagement structure are rotatably engaged, and the sensor being electrically disconnected from the computing unit when the first engagement structure and the second engagement structure are not rotatably engaged.

41. The first component of claim 24, wherein the second component comprises a terminal end of a cable including a plurality of conductors, the conductors of the cable being electrically interconnected with the first component when the first engagement structure and the second engagement structure are rotatably engaged, and the conductors of the cable being electrically disconnected from the computing unit when the first engagement structure and the second engagement structure are not rotatably engaged.

42. The first component of claim 24, wherein the first engagement structure and the second engagement structure include complementary threaded structures.

43. The first component of claim 24, wherein the tool assembly has a substantially tubular shape of substantially uniform outside diameter at a location where the first component and the second component are physically secured when the first engagement structure and the second engagement structure are rotatably engaged.

44. The first component of claim 24, wherein the first component and the second component are assembled into the tool assembly.

45. The first component of claim 24, wherein the first component includes the multiple connector unit.

46. A tool assembly adapted for insertion into a well or other hole to monitor at least one condition existing in the well or other hole, the tool assembly comprising:

at least one sensor operable to provide a sensor reading of at least one monitored condition, the sensor reading comprising a sensor output signal including sensor reading data corresponding to the at least one monitored condition;

a computing unit including a processor and memory having stored therein instructions readable and executable by the processor, the computing unit being operably connected with the sensor so that the computing unit is capable of receiving and processing the sensor reading data;

a terminal end of a cable, the cable including a plurality of communication lines operably connected with the computing unit so that the computing unit is capable of directing at least one communication function selected from (i) transmission of a communication signal via the communication lines and (ii) receiving a communication signal via the communication lines;

the tool assembly including at least two components assembled to form the tool assembly, a first component including at least the computing unit and the second component including at least one of the sensor and the terminal end of the cable, the first component and the second component being engaged through rotatable engagement of a first engagement structure of the first component and a complementary second engagement structure of the second component;

the rotatable engagement of the first engagement structure and the second engagement structure physically secures the first component to the second component and makes an electrical connection between the first component and the second component through an electrical interconnection structure including a multiple connector unit disposed between and in contact with a first plurality of electrical leads in the first component and a second plurality of electrical leads in the second component, the electrical interconnection structure, and the electrical connection, being broken when the first engagement structure and the second engagement structure are rotatably disengaged.

47. Tool assembly of claim 46, wherein the first component includes a first housing in which is disposed the computing unit and the second component includes a

second housing in which is disposed at least one of the sensor and the terminal end of the cable; and

the first engagement structure comprises a first threaded portion of the first housing and the second engagement structure comprises a complementary second threaded portion of the second housing.

48. The tool assembly of claim 46, wherein the first component includes the computing unit and the sensor disposed within the first housing and the second component includes the terminal end of the cable disposed within the second housing.

49. The tool assembly of claim 47, wherein the tool assembly includes at least three components, the first component including the computing unit disposed within the first housing, the second component including the sensor disposed within the second housing, and a third component including the terminal end of the cable disposed within a third housing;

the first housing having a first longitudinal end and a second longitudinal end, the first engagement structure being located adjacent the first longitudinal end;

the multiple connector unit being a first multiple connector unit, the rotatable engagement being a first rotatable engagement, the electrical connection being a first electrical connection, and the electrical interconnection structure being a first electrical interconnection structure;

the first component and the third component being engaged through a second rotatable engagement of a third engagement structure on the third component and a complementary fourth engagement structure on the first component, the third engagement structure comprising a third threaded portion of the third housing and the fourth engagement structure comprising a complementary fourth threaded portion of the first housing, the fourth threaded portion being located at the second longitudinal end of the first housing;

the second rotatable engagement physically secures the third component to the first component and makes a second electrical connection between the third component and the first component through a second electrical interconnection structure including a second multiple connector unit disposed between and in contact with a third plurality of electrical leads in the third component and a fourth plurality of electrical leads in the first

component, the second electrical interconnection structure being broken when the third engagement structure and the fourth engagement structure are rotatably disengaged.

50. The tool assembly of claim 46, wherein the tool assembly is capable of being connected, via the cable, into a network including at least a second like tool assembly, the computing unit being capable of directing transmission of a communication signal via the cable to the second like tool assembly to direct the second like tool assembly to perform an operation involving the obtainment of a sensor reading from the sensor of the second like tool assembly.

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51. A networkable tool adapted for insertion into a well or other hole to direct monitoring by the tool of at least one condition existing in the well or other hole, the component comprising:

an elongated housing having a first longitudinal end and a second longitudinal end;

a computing unit disposed within the housing, the computing unit including a processor and memory containing stored instructions readable and executable by the processor during operation of the tool;

a sensor operably connected with the computing unit so that the computing unit is capable of directing obtainment of sensor readings from the sensor with each said sensor reading including a sensor output signal containing sensor reading data, processable by the computing unit, corresponding to the at least one monitored condition; and

a communication interface, disposed within the housing, through which the computing unit is operably connectable to a communications network, wherein messages may be exchanged with at least one other device in connection with the communications network.

52. The tool of claim 51 wherein the at least one other device comprises a central controller, wherein the central controller is configured to the tool through exchange of the data messages over the communications network.

53. The tool of claim 51 wherein, the computing unit is capable of directing at least one communication function when the tool assembly is connected in the communications network, the at least one communication function comprising transmitting, a communication signal to direct at least one other like tool to perform an operation.

54. The tool of claim 51 wherein the communications interface and computing unit are configured to receive and process messages received over the communications network which include a unique address header.

55. The tool of claim 54 wherein the computing unit is configured to operate the tool in a sleep and awake mode, wherein the computing unit will transition from the sleep to the awake mode upon detection the unique header in the message received over the network.

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56. The tool of claim 51 wherein the computing unit is further configured to monitor message traffic over the communications network, such that outgoing messages generated by the computing which are to be transmitted over the communications network will only be transmitted when none of the message traffic is detected.

57. The tool of claim 56 wherein the computing unit will wait a random period of time before attempting to transmit the outgoing message when message traffic is detected.

58. The tool of claim 51 wherein the instructions stored in memory may be replaced, amended, and/or deleted in response to receipt of a message over the communications network.

59. The tool of claim 51 wherein the memory comprises first and second flash memories and the computing unit is further configured to overwrite the instructions stored in first flash memory in response to one or more of the messages received over the communications network, such that when a particular message is received at the communications interface which includes new instructions, the new instructions are loaded in the second flash memory, and when the loading is complete, the computing unit is activated and overwrites the instructions in the first memory with the new instructions from the second memory.

60. A tool adapted for insertion into a well or other hole to direct monitoring of at least one condition existing in the well or other hole, the tool comprising:

an elongated housing;

a computing unit disposed within the housing, the computing unit including a processor and memory containing stored instructions readable and executable by the processor to direct at least one operation of the component;

a sensor operably connected to the computing unit so that the computing unit is capable of directing obtainment of sensor readings from the sensor, with each said sensor reading including at least one sensor output signal containing sensor reading data, processable by the computing unit,

corresponding to at least one monitored condition;

wherein the computing unit is capable of directing the obtainment of sensor readings according to at least two different sampling schedules.

61. The tool of claim 60, wherein the computing unit is capable of directing a switch from a first sampling schedule to a second sampling schedule in response to identification by the computing unit of the occurrence of a predefined event.

62. The tool of claim 60, wherein the first sampling schedule includes a longer time interval between sensor readings than the second sampling schedule;

the predefined event being a specified change between sensor readings during the first sampling schedule.

63. The tool of claim 60, wherein the sensor includes a pressure sensor and the predefined event is a specified change between pressure readings during the first sampling schedule.

64. The tool of claim 60, wherein, when the computing unit directs a switch from the first sampling schedule to the second sampling schedule, a data tag identifying commencement of the second sampling schedule is stored in the memory.

65. The tool of claim 64, wherein data points each corresponding with one of the sensor readings during the first sampling schedule and the second sampling schedule is stored in the memory, the data tag being stored with a data point marking commencement of the second sampling schedule.

66. The tool of claim 65, wherein the data points are stored in memory only during the second sampling schedule, and the firs sampling schedule is employed as a monitoring period to detect the occurrence of the predefined event.

67. The tool of claim 64, wherein substantially all of the data points from the first sampling schedule and the second sampling schedule stored in the memory are stored in a single data file.

68. The tool of claim 64, wherein at least some of the data points stored in the memory from each of the first sampling schedule and the second sampling schedule are stored in the memory without a time tag identifying the time at which the corresponding sensor readings are taken.

69. The tool of claim 60, wherein the computing unit processes the sensor reading data at a voltage of smaller than about 4 volts.

70. The tool of claim 60, wherein the computing unit further comprises a real time clock/calendar and the tool is operable in a sleep mode and an awake mode;

when operating in the awake mode, the real time clock/calendar and the processor are operably connected, and when operating in the sleep mode the real time clock/calendar and the processor are operably disconnected;

the component operates in the awake mode to obtain sensor readings and in the sleep mode between sensor readings, to conserve energy; and

the second sampling schedule has a shorter interval between sensor readings than the first sensor reading, so that power consumption during the second sampling schedule is increased relative to the first sampling schedule.

71. The tool of claim 60, wherein the housing has a longitudinal axis and a cross-section of the housing taken perpendicular to the longitudinal axis at any location fits entirely within a circle having a diameter of smaller than about 0.8 inch.

72. The tool of claim 60, wherein the housing is substantially tubular in shape having an outside diameter of smaller than about 0.8 inch.

73. The tool of claim 60, wherein the processor comprises a microprocessor chip having a length dimension, a width dimension and a thickness dimension, with the width dimension being no larger than about 0.6 inch.

74. A method for field monitoring at least one condition, the method comprising:

field monitoring at least one field condition with a plurality of field deployed monitoring units, including at least a first monitoring unit and a second monitoring unit, operably connected in a network;

each said monitoring unit comprising an elongated housing and a computing unit disposed within the housing, the computing unit including a processor and memory having stored therein instructions readable and executable by the processor to direct at least one operation of the monitoring unit;

each said monitoring unit further comprising at least one sensor operably connected with the computing unit, the field monitoring step including operation of at least the first monitoring unit, at the direction of the computing unit of the first monitoring unit, to obtain sensor readings from the sensor of the first monitoring unit, each said sensor reading including generating by the sensor at least one sensor output signal containing sensor reading data corresponding to the at least one field monitored condition;

wherein, when the computing unit of the first monitoring unit identifies the occurrence of a predefined event according to instructions stored in the memory of the first monitoring unit, the computing unit of the first monitoring unit directs the transmission of a communication signal to cause the second monitoring unit to perform a predefined monitoring operation comprising obtainment of a sensor reading at the direction of the computing unit of the second monitoring unit.

75. The method of claim 74, wherein the first monitoring unit includes at least a pressure sensor capable of sensing the pressure of a liquid head in fluid communication with the pressure sensor, the predefined event comprising a predefined increase in sensor readings from the pressure sensor obtained by the computing unit of the first monitoring unit.

76. The method of claim 74, wherein the first monitoring unit includes at least a first sensor to sense a first field condition and the second monitoring unit includes at least a second sensor to sense a second field condition that is different than the first field

condition, the predefined monitoring operation comprising obtainment of a sensor reading from at least the second sensor.

77. The method of claim 76, wherein the first field condition is pressure and the second field condition is at least one condition of an aqueous liquid selected from the group consisting of oxidation-reduction potential, pH, electrical conductivity, the presence of at least one specific chemical component, turbidity and chlorophyll content.

78. The method of claim 77, wherein the at least one condition of the aqueous liquid is the presence of at least one component selected from the group consisting of nitrate ions, sulfate ions, chloride ions, and dissolved oxygen.

79. The method of claim 74, wherein each said monitoring unit is disposed inside of a different monitoring well.

80. The method of claim 79, wherein each said monitoring unit is suspended from a cable including communication lines through which each said monitoring unit is connected into the network.

81. The method of claim 80, wherein each said monitoring unit is in fluid communication with the atmosphere above the monitoring well via a fluid path extending through the cable.

82. The method of claim 80 further comprising supplying power to the network from an external power source at a voltage of larger than about 10 volts and stepping down the external power to a voltage of smaller than about 4 volts for use to operate each said monitoring unit.

83. The method of claim 82, wherein each said cable is connected with at least one network interconnection cable operating at a voltage of higher than about 10 volts and each said cable operating at a voltage of from about 5 volts to about 8 volts; and

the stepping down comprises first stepping down the voltage from larger than about 10 volts to from about 5 volts to about 8 volts prior to supplying the external power to the cables, and the stepping down further comprising second stepping down the voltage of the cables from a range of from about 5 volts to about 8 volts to a voltage of smaller than about 4 volts, prior to use of the external power for operation of each said monitoring unit.

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84. The method of claim 83, wherein each said cable is connected with the at least one network cable at a junction disposed within a junction box, the first stepping down occurring inside the junction box corresponding with the cable.

85. The method of claim 84, wherein the second stepping down occurs within the monitoring unit.

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